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Interface Specification

INNER TRIPLET FEEDBOXES: DFBX – TUNNEL AND ALIGNMENT INTERFACE

Abstract

This specification establishes the detailed interface requirements for the transportation, installation and alignment of the DFBX feedboxes including mounting to the tunnel floor, lifting points and Taylor-Hobson fiducials.

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History of Changes

Rev. No.	***Date***	***Pages***	***Description of Changes***
1.0	2001-10-17		Initial submission.
1.1	2002-01-04	8	Added text on alignment.
		9	Tables 8-1,2 tolerances and notes changed.
		10	Added text on alignment.
		11	Added reference [i].
1.2	2002-01-23	4	Increased limits on alignment tolerances in X and Z directions.
		8	Updated positional and rotational allowable misalignments.
		9	Updated tables 8-1 and 8-2.
1.3	2002-03-19	5	Updated table 3-1 to reflect optics version 6.4. Updated table 4-1. Added fiducials to components already installed on DFBX.
		8	Updated misalignment limits; replaced Taylor-Hobson fiducial on tunnel side of DFBX with reference surface on aisle-side.
		9-10	Updated figure 8-1, and tables 8-1 and 8-2.
		10	Added grub screws to bumper bracket and revised realignment procedure for change of DFBX Y-position.
		11	Revised Figure 9-3.
		12	Added Figure 9-4. Updated drawing list to optics version 6.4.
	2002-04-10	all	Submission for approval
1.4	2002-05-23	10	Added IP distance for absolute position of DFBX and fiducials.
		13	Added rating of ISR jacks.
		15	Changed drawing reference [i] to LHCGIMSA_0007, reference socket for DFBX.
	2002-06-04	All	Released Version

Table of Contents

1. INTRODUCTION

All DFBX boxes in the LHC ring will have to be transported to their operating locations in the tunnel, installed, aligned, and secured to the tunnel floor. Each DFBX may be lifted from above by overhead crane or from below by forklift. (See Section 5.) Two Taylor-Hobson fiducials and a reference surface will be used to align each of the boxes once in position on the tunnel floor. Alignment is required to be ±1.0 mm in X, Y and Z. Range of adjustment for the DFBX on the IRS jacks is ±10 mm in all three directions.

2. DFBX EQUIPMENT CODES

Because each of the eight DFBX has a unique design, the following equipment codes have been adopted facilitating a direct application of the LHC documentation system. In the table, "IRnR" signifies the right side of the Interaction Point n, and "IRnL" signifies the left side of Interaction Point n.

Location	IR1 L	IR1 R	IR2 L	IR2 R	IR5 L	IR5 R	IR8 L	IR8 R
Code	DFBXA	DFBXB	DFBXC	DFBXD	DFBXE	DFBXF	DFBXG	DFBXH

3. CO-ORDINATE SYSTEM

The local coordinate systems used in this specification with respect to the DFBX are given in the DFBX General Interfaces Specification [1] and shown in the figures below. The local coordinate system is defined by the following:

- X=0, Z=0 at center of beam line.
- Y=0 at front face of flange.
- Positive X is toward the machine center.
- Positive Y is in clockwise beam direction.
- Positive Z is vertical up from LHC plane.

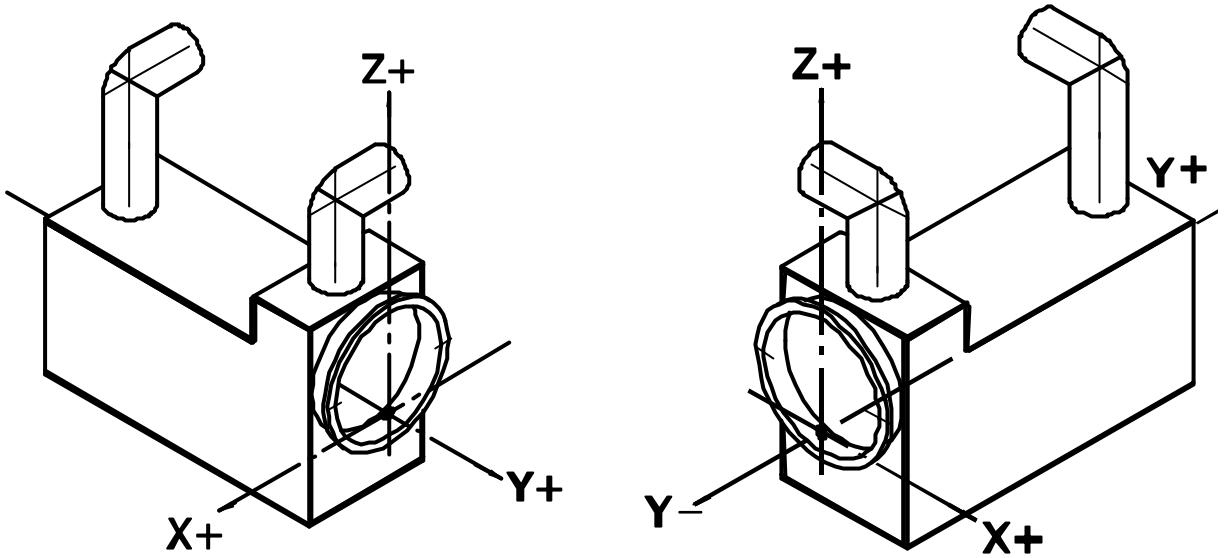

Figure 3-1. DFBX co-ordinate system – left and right sides of IP.

The origins of the DFBX local coordinate systems with respect to the CERN global coordinates are listed in Table 3-1. In deriving these locations we use the referenced CERN drawing and set the flange to flange separation between the DFBX and the LQX to be 510 mm [2].

Table 3-1. Position of DFBX Local Coordinate Systems

Code	Distance (mm) from IP	CERN Dwg. No.	Dwg. Ref. List
DFBXA	55052 Left of IP1	LHCLSX__0001F	[a]
DFBXB	55052 Right of IP1	LHCLSX__0002F	[b]
DFBXC	55052 Left of IP2	LHCLSX__0003F	[c]
DFBXD	55052 Right of IP2	LHCLSX__0004F	[d]
DFBXE	55052 Left of IP5	LHCLSX__0009F	[e]
DFBXF	55052 Right of IP5	LHCLSX__0010F	[f]
DFBXG	55052 Left of IP8	LHCLSX__0015F	[g]
DFBXH	55052 Right of IP8	LHCLSX__0016F	[h]

4. SHIPPING CONFIGURATION

The DFBX is supported in a shipping crate on soft-mounts designed to minimize shock and vibration transmitted to the DFBX assembly during transport. Each crate contains two DFBX assemblies and the associated mounting components and hardware. (The first two DFBX assemblies will be shipped separately.) The I.S.R. jacks used for mounting the DFBX to the tunnel floor and the bumper brackets used to restrain the DFBX under thrust loads will be labelled and packed in a box shipped with the DFBX. A spreader bar which attaches to four hoist rings at the upper corners of the DFBX will be packaged with the first DFBX and retained for lifting each DFBX assembly. Taylor-Hobson fiducial bases and the reference surface are installed on the DFBX and protected by shipping covers. Table 4-1 lists components shipped with the DFBX for installation. After the hardware fastening the shipping mounts to the crate and the DFBX is removed, the DFBX may be lifted off the mounts using an overhead crane and the DFBX spreader bar.

Table 4-1 DFBX and components packaged with each DFBX assembly.

Component	Quantity	Responsibility
DFBX Assembly	1	LBNL
I.S.R. jack	3	LBNL
Floor anchor (Hilti-type)	24	CERN
Spreader bar lifting fixture[1]	1	LBNL
Rollers for DFBX[1,2]	2	CERN
Collapsible transfer table[1]	1	CERN
Tie rod bracket and hardware set	4	LBNL
Bumper bracket and hardware ass'y	3	LBNL

1. One unit provided for use with all 8 DFBX.
2. Required if DFBX transported through tunnel TI2.

5. LIFTING

Figure 5-1 shows the locations of the hoist rings on the DFBX box. The DFBX will be shipped with the four hoist rings installed. The approximate mass of the assembled DFBX is 6 Tonnes. A special lifting fixture, including spreader bar and cables, is provided with the first DFBX to protect the current leads and equipment on the top of the box during lifting. The same lifting fixture can be used for all eight DFBX. Figure 5-2 is a sketch of the lifting fixture. The distance from the bottom of the DFBX to the crane hook is 3.35 meters. The DFBX box should only be lifted using this fixture and the DFBX hoist rings. Since the assembled DFBX box contains precisely-positioned pipes of various diameters supported in place by G-10 spiders, it is important that the box is lifted and lowered in a smooth and gradual motion to minimize shock loads to the internal equipment. Acceptable levels of shipping and transfer loads are listed in Table 5-1. The DFBX vacuum vessel and shipping crate will be instrumented with shock indicators. The shipping crate will be equipped with soft-mounts to reduce general transport loads to acceptable levels. The shock sensors will indicate the maximum levels seen on the vacuum vessel during transport and transfer.

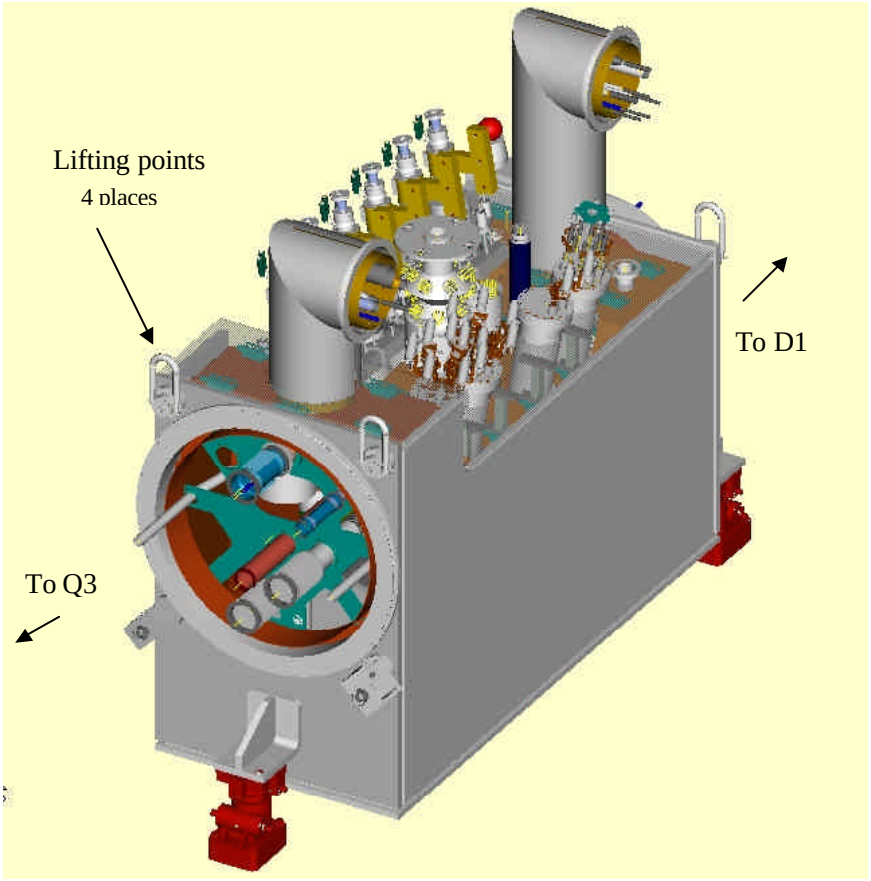

Figure 5-1 Lifting Point Locations on the DFBXC. (Locations are the same for all DFBX.)

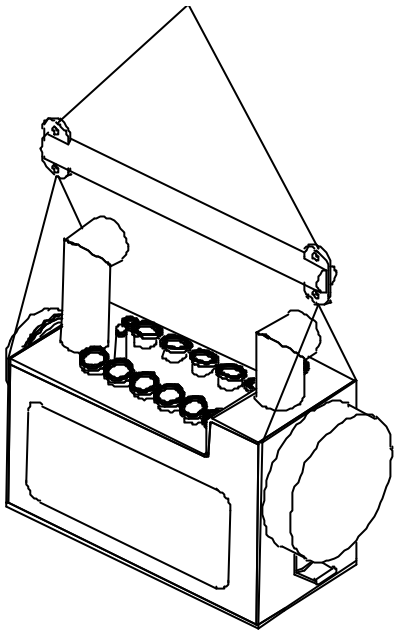

Figure 5-2 Sketch of spreader bar for DFBX.

Table 5-1 Maximum acceptable transport and transfer loads for the DFBX.

Direction of load*	**DFBX in crate (g's)**	**DFBX alone (g's)**
Lateral (±X)	£ **1**	£ **1**
Vertical (±Z)	£ **2**	£ **1**
Axial (±Y)	£ **4**	£ **1**

***According to the coordinate system in Figure 3-1.**

6. TRANSPORTING DFBX TO OPERATING LOCATION

Once uncrated and at the LHC ring access position, the DFBX should be lifted by overhead crane onto a CERN transport cart using the DFBX lifting fixture and hoist rings. The box should be lowered onto the cart in accordance with the allowable loads outlined above. The cart will be used to move the box adjacent to its location in the ring.

Because of its height (2071 mm from the bottom of the box to the top of the QRL chimneys), the DFBX may require a low transport vehicle or rollers mounted directly to the DFBX, if routed through the injection region tunnel, TI2 (1.5 m radius). The footprint of the DFBX vacuum vessel is 2.2 meters by 1.0 meter. For general transport, the cart height should be no greater than 32 cm to stay within the tunnel transport space.

7. INSTALLATION OF DFBX BOX

Before installing the DFBX, the base of each of the supporting jacks must be installed in place on the tunnel floor. They are attached to the tunnel floor with 4 Hilti-type anchors, each rated for 29.4 kN (6600 lbs).

Two jacks are located near the corners of the LBX end of the box, and the third is centered on the LQX end. Figure 7-1 shows a sketch of the jack placement. The upper portion of the jacks mount to the bottom of the brackets welded on the DFBX vessel as shown in Figure 7-1. These rest on the jack bases to support the DFBX assembly. Once the jack bases are secured to the floor, the DFBX may be moved from the transporter cart onto the jacks using a special collapsible transport table. The box is supported on the spherical bearing surfaces of the three jacks simulating a kinematic support condition. The jacks are manually adjusted (±10 mm in three directions) and can be accessed at each end of the box. The jacks will be installed with alignment screws at mid-height. Hoist rings, and the protective covers on the current leads, alignment fixtures, and feedthroughs should be removed once the DFBX is installed.

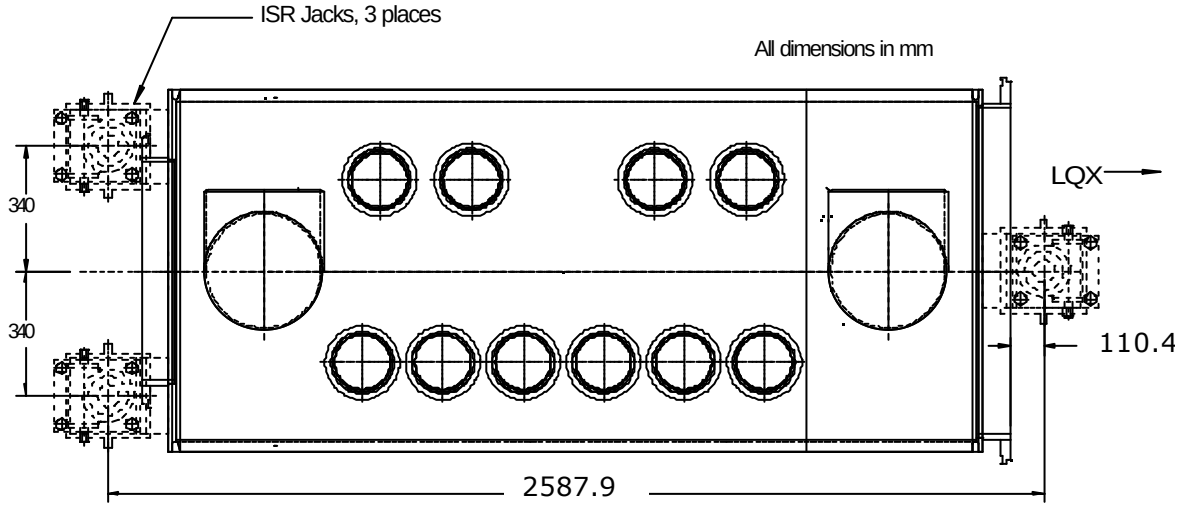

Figure 7-1 Support Jack Placement for the DFBX. (Box shown is for DFBXC,G; dimensions are identical for all other DFBX boxes.)

8. ALIGNMENT

With the box supported on the jacks, the DFBX will be aligned using two Taylor-Hobson fiducial assemblies, [i], and a reference surface mounted to the top of the DFBX box (See Figure 8-1). The fiducial bases and the reference surface are installed and fiducialized on the DFBX during assembly. Protective covers are used for shipping and should be removed before aligning the DFBX box. Each DFBX should be positioned with the origin of its local coordinate system, the exit face of the LQX flange at the center of the beam tube, 55052 mm from its associated IP. (See Table 3-1.) This corresponds to fiducial #1 being located 55832 mm from the IP and fiducial #2 being located 57254.6 mm from the IP.

The tolerances for the DFBX X,Y and Z positions are:

dX = ± 1.0 mm, dY = ± 1.0 mm, dZ = ± 1.0 mm.

The maximum allowable rotational misalignments are:

dPitch (rotation about X) = ± 0.65 mrad

dYaw (rotation about Z) = ± 0.65 mrad

The maximum allowable rotational misalignment is:

dRoll (rotation about Y) = ± 1.1 mrad

Tables 8-1 and 8-2 give locations for the fiducials and their tolerances relative to the DFBX local coordinate system.

Realignment may be performed under vacuum or at ambient pressure, and under warm or cold conditions. Guidelines for realignment are discussed in Section 9. Alignment tolerances for the QRL, LQX and LBX interfaces are addressed in [2-4]. These tolerances allow for up to 4 mm of flexibility during alignment.

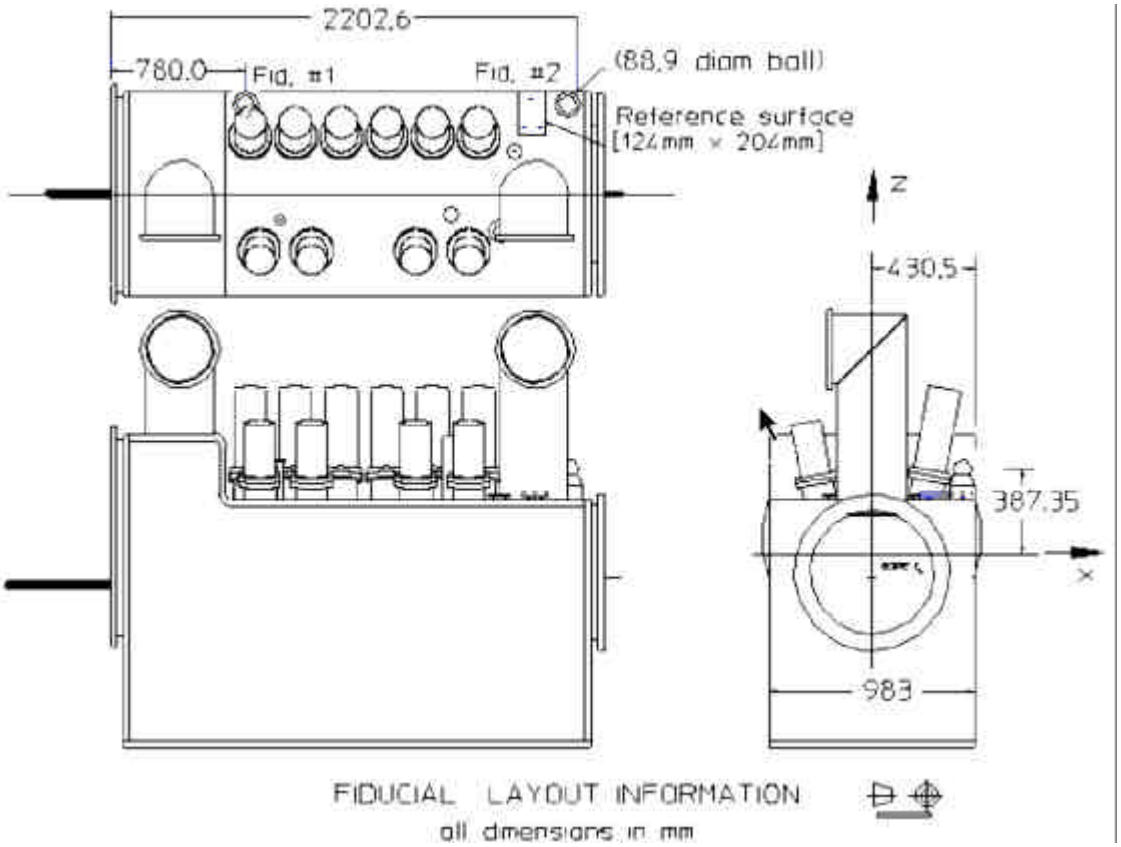

Figure 8-1. View of Taylor-Hobson Fiducials and reference surface on DFBXC and G.

Table 8-1. Locations of fiducials for all DFBX left of the IP.*

Fiducial	X – location ± 0.5 mm	Y – location ± .5 mm	Z – location ± 0.13 mm
#1	430.5	-780.0	387.35
#2	430.5	-2202.6	387.35

***** Locations are relative to the left side coordinate system shown in Figure 3-1. Exact X and Y locations for each fiducial will measured to the nearest 0.13 mm and recorded in the traveller for each DFBX. All fiducials will be set to the same Z-location. The reference surface will be set parallel to the X-axis within 0.6 mrads.

Table 8-2. Locations of fiducials for all DFBX right of the IP.*

Fiducial	X – location ± 0.5 mm	Y – location ± 0.5 mm	Z – location ± 0.13 mm
#1	430.5	780.0	387.35
#2	430.5	2202.6	387.35

***** Locations are relative to the right side coordinate system shown in Figure 3-1. Exact X and Y locations for each fiducial will measured to the nearest 0.13 mm and recorded in the traveller for each DFBX. All fiducials will be set to the same Z-location. The reference surface will be set parallel to the X-axis within 0.6 mrads.

9. INSTALLATION OF BUMPER AND TIE ROD BRACKETS

With the DFBX box installed and aligned, the bumper brackets may be installed in the locations shown in Figures 9-1 and 9-2. The bumper bracket shown in Figure 9-3 is designed to keep the box in place under vacuum thrust and catastrophic pressure loads while preserving the box alignment in the Y-direction. Four grub screws (Figure 9-4) on each bumper bracket are adjusted to make contact with the box end and secured with jam nuts. The brackets are attached to the tunnel floor using four anchors. Each anchor is rated to withstand a pullout load of 29.4 kN (6690 lbs). The bumper brackets can be positioned near the ends of the DFBX with the screws adjusted to contact the ends of the box, allowing the mounting holes for each bracket to be marked in place on the floor. The brackets are removed to drill and insert the anchors; then replaced and bolted down. Since the bumpers restrain box movement only in the Y-direction, they allow movement of the box in the Z and X directions and should not interfere with realignment in the vertical and lateral directions. The ISR jacks are each rated at 15 metric tonnes. The DFBX estimated mass is 6.5 tonnes. Therefore, each jack is designed to lift over twice the mass of the DFBX. Even with the friction load from the bumper brackets, the jacks have sufficient margin to permit repositioning the DFBX in the X-Z plane. If the Y-position of the box needs to be changed the grub screws on each bracket can be adjusted to accommodate changes in the longitudinal position.

Four tie rods connecting the LQXC cryostat to the DFBX box are used to react vacuum thrust loads from the LQXC and possible thrust loads induced by an overpressure of the LQXC. The bumper brackets used to secure the DFBX to the tunnel floor are designed to react these loads. The D1 magnet support jacks are able to resist vacuum loads, thus no external tie bars are required on the LBX side.

The two lower tie rod brackets are shipped assembled to the DFBX; the upper tie rod brackets and mounting hardware are shipped in a box inside the DFBX crate. The upper tie rod brackets mount to the hoist ring bosses on the LQX side of the DFBX. The hoist rings must be removed to install the upper tie rod brackets. The tie rods extending from the LQX may be attached to the tie rod brackets once the DFBX has been installed, aligned and pipe connections to the LQXC completed. (These rods may make interconnecting the piping between the DFBX and LQXC difficult if installed first.) The tie rods are designed to pivot in the bracket until secured using a spherical washer and a double-nut arrangement. It is not necessary to remove the tie rods to realign the DFBX. All that is required for realignment is that the nuts be loosened to allow repositioning of the DFBX.

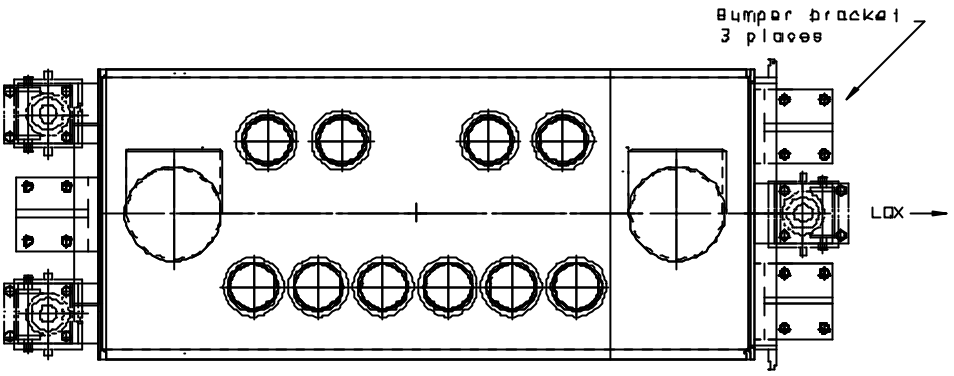

Figure 9-1. Typical bumper bracket locations shown on DFBXC and G; locations are the same for DFBXA and E. For exact

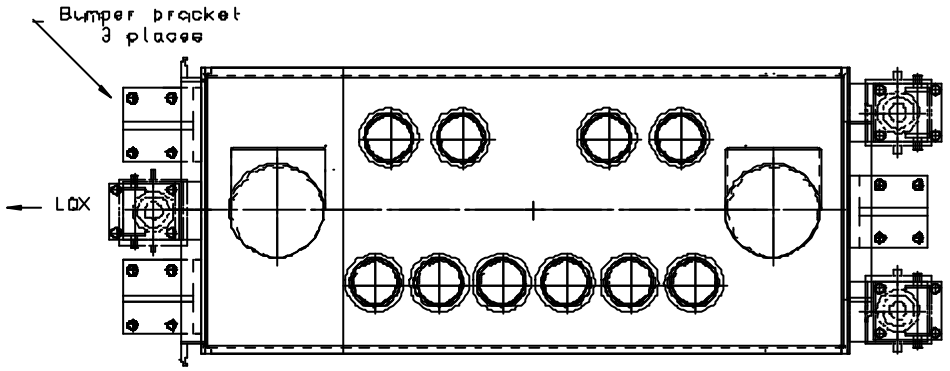

Figure 9-2. Typical bumper bracket locations shown on DFBXD and H; locations are the same for DFBXB and F.

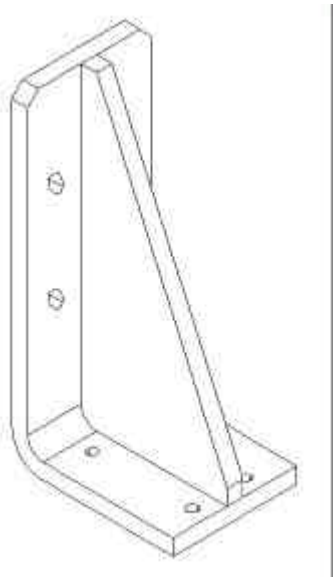

Figure 9-3. Bumper bracket with holes for grub screws.

Figure 9-4. Grub screw.

10. INTERCONNECTS

Once the DFBX has been aligned and the bumper brackets installed, the pipe connections to the adjacent components may be made [2-7].

11. DRAWINGS

a. LHCLSX__0001F, LAYOUT OF LSS V.6.4 – IR1 LEFT, 15 March 2002.
b. LHCLSX__0002F, LAYOUT OF LSS V.6.4 - IR1 Right, 15 March 2002.
c. LHCLSX__0003F, LAYOUT OF LSS V.6.4 - IR2 Left, 15 March 2002.
d. LHCLSX__0004F, LAYOUT OF LSS V.6.4 - IR2 Right, 15 March 2002.
e. LHCLSX__0009F, LAYOUT OF LSS V.6.4 - IR5 Left, 15 March 2002.
f. LHCLSX__0010F, LAYOUT OF LSS V.6.4 - IR5 Right, 15 March 2002.
g. LHCLSX__0015F, LAYOUT OF LSS V.6.4 - IR8 Left, 15 March 2002.
h. LHCLSX__0016F, LAYOUT OF LSS V.6.4 - IR8 Right, 15 March 2002.
i. LHCGIMSA0007 Reference Socket Assembly, 26 May 1997.

12. REFERENCES

1. LHC Engineering Specification, "Inner Triplet Feedboxes General Interfaces", LHC-DFBX-ES-0200.00.
2. LHC Engineering Specification, "Interface Specification: Inner Triplet Feedboxes DFBX to LQX", LHC-DFBX-ES-0210.00.
3. LHC Engineering Specification, "Interface Specification: Inner Triplet Feedboxes DFBX to LBX", LHC-DFBX-ES-0230.00.
4. LHC Engineering Specification, "Interface Specification: Inner Triplet Feedboxes DFBX to QRL", LHC-DFBX-ES-0240.00.
5. LHC Engineering Specification, "Interface Specification: Inner Triplet Feedboxes DFBX – Power Converters", LHC-DFBX-ES-0250.00.
6. LHC Engineering Specification, "Interface Specification: Inner Triplet Feedboxes Electrical Signals", LHC-DFBX-ES-0270.00.
7. LHC Engineering Specification, "Interface Specification: DFBX to Helium Gas Recovery", LHC-DFBX-ES-0280.00.